Comparison of Ashtech Z-12 and Trimble 4000SSI
Used as Time Space Position Information (TSPI) Systems

Cliff Mackin, ACT-360, William J. Hughes Technical Center

Background

The comparison of the Trimble 4000SSI and the Ashtech Z-12 differential GPS TSPI systems was conducted by ACT-360 from February, 1996 through September, 1996. Previous testing[1] established the accuracy and viability of the Ashtech Z-12 as an aircraft positioning truth source for use in flight testing navigation and approach systems. The subject tests were conducted to determine the accuracy and viability of the Trimble 4000SSI as an aircraft positioning truth source by comparing 4000SSI flight and static data with similar data taken simultaneously from an Ashtech Z-12. Comparison flight data were collected using three aircraft, a Falcon 20 fanjet owned and operated by the National Research Council of the Canadian government, an FAA Convair 580 turboprop (N39), and an FAA Beech 300 turboprop (N35). The flight data were collected at two locations: the William J. Hughes Technical Center (ACY), Atlantic City, NJ, and the Pullman-Moscow Regional airport (PUW), Pullman, Washington. Comparison static data were collected at the William J. Hughes Technical Center using a first order National Geodetic Survey NGS) monument located on the Technical Center property.

Test Description and Results

General

Statically and dynamically, the systems were deployed such that both Ashtech and Trimble rover units shared a common antenna as did the reference station units. This was done to eliminate the need for antenna placement corrections between the systems. In all cases, system data, WGS-84 latitude, longitude, and ellipsoid height, were recorded along with the system GPS time at a one Hertz rate. The data recorded from each system was post processed using proprietary software from the respective equipment manufacturers. The two sets of data were then merged using time as the common base. For this test, the 4000SSI data was compared only to the Z-12 data; the data was not compared to any other truth source such as a laser tracker. Previous testing[1] established the accuracy of the Z-12 as a TSPI system and as an aircraft positioning truth system. For all testing at the William J. Hughes Technical Center, the reference station was located at a precisely known survey point derived from the first order NGS monument grid at the William J. Hughes Technical Center. A precision reference point was established at PUW using the published runway threshold coordinates for that airport. The Trimble 4000SSI is a modular system, physically similar to the Ashtech Z-12. The system is easily deployed and setup and data processing are user friendly.

Static Data

A total of 8.74 hours of static data were collected on two different days by locating the rover units at a precisely known first order NGS surveyed monument (GLASCOW) on the William J. Hughes Technical Center property. The baseline distance between the rover and refeence points was 2186 meters. The initial set of static data were collected on 09/18/96 using only the Trimble 4000SSI. Therefore, the only comparison made for this data is between the position reported by the 4000SSI and the known position of the GLASCOW monument. The second set of static data

were collected using both the Trimble 4000SSI and the Ashtech Z-12 deployed in the flight data collection mode. This data is presented three ways: it is compared to the known position of the GLASCOW monument for both systems; and a comparison is also made between the positions reported by the two systems. Results of the static data are summarized in Table 1. The individual static data comparisons are graphically displayed in figures 1-4. The scatter plots show each data point as either a northing or altitude difference versus easting difference on a scale of +/- 0.2 meters. Horizontal and vertical pairs of crosshair lines portray the mean plus standard deviation and the mean minus standard deviation for each axis. A normal distribution for each axis is also shown. The grouping of the sample population within difference circles of radius 5, 10, and 20 cm is listed on each plot as well as those points outside of a 20 cm circle. In all cases of the static data, at least 98% of the lateral and 94% of the vertical difference data is grouped within a 10 cm circle.

Flight Data

A total of 10.63 hours of flight data were collected over five different flights. For all of the flights, the flight profiles were a series of approaches to runways at the airport indicated. The maximum range that any of the test aircraft flew from the airports during the data collection was 25 nautical miles at an altitude of 3000 feet above ground level. Flight data was continuously recorded for all phases of flight from engine start to shut down. This included taxi, takeoff, climb out, outbound, approach, landing, and roll out. Results of the flight data are summarized in Table 2. The individual flight data comparisons are graphically displayed in figures 5-9. The scatter plots show each data point as either a northing or altitude difference versus easting difference on a scale of +/- 0.2 meters. Horizontal and vertical pairs of crosshair lines portray the mean plus standard deviation and the mean minus standard deviation for each axis. A normal distribution for each axis is also shown. The grouping of the sample population within difference circles of radius 5, 10, and 20 cm is listed on each plot as well as those points outside of a 20 cm circle. In all but one of the flights, at least 98% of the lateral difference data is within 10 cm and at least 99% of the vertical difference data is within 20 cm. The flight data which falls outside of this grouping (04/25/96) was collected at the William J. Hughes Technical Center during a period of local interference to the GPS L2 signal[2]. The difference data from this flight are not grouped as tightly as on the other flight data samples, but still contain over 99% of the lateral data and 90% of the vertical data within a circle of 20 cm radius. The source of this interference has since been eliminated and it is not possible to determine from the data collected which of the two TSPI systems were more adversely affected. Additionally, a trend in the flight data may also be present which implies that multipath from the test aircraft propellers may affect the data grouping. The tightest difference data recorded was from the F20 test aircraft which has no propellers. The BE-300 and CV-580 test aircraft are both propeller driven aircraft, with the CV-580 having especially large propellers. It is anticipated that further testing will be conducted to determine the existence and magnitude of this effect on GPS TSPI data.

Conclusions

1. The Trimble 4000SSI, used as a TSPI system, demonstrated horizontal and vertical accuracies comparable to those established for the Ashtech Z-12[1].

2. The Trimble 4000SSI, used as a TSPI system, is well suited for use as an aircraft positioning system for flight testing of navigation and landing guidance systems.

References

1. Youngdahl, G.E., *Flight Test of Ashtech GPS Receiver For Use as Time Space Position Information System (TSPI) To Verify Specific Performance Standards,* January 1995

2. Hoang, Kiem, *Radio Interference to Global Positioning System on L2 at the Federal Aviation Administration Technical Center*, April 1996